5.

The Vampyromorpha (Cephalopoda) of the Bermuda Oceanographic Expeditions.[1]

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(Text-figures 1-8).

INTRODUCTION.

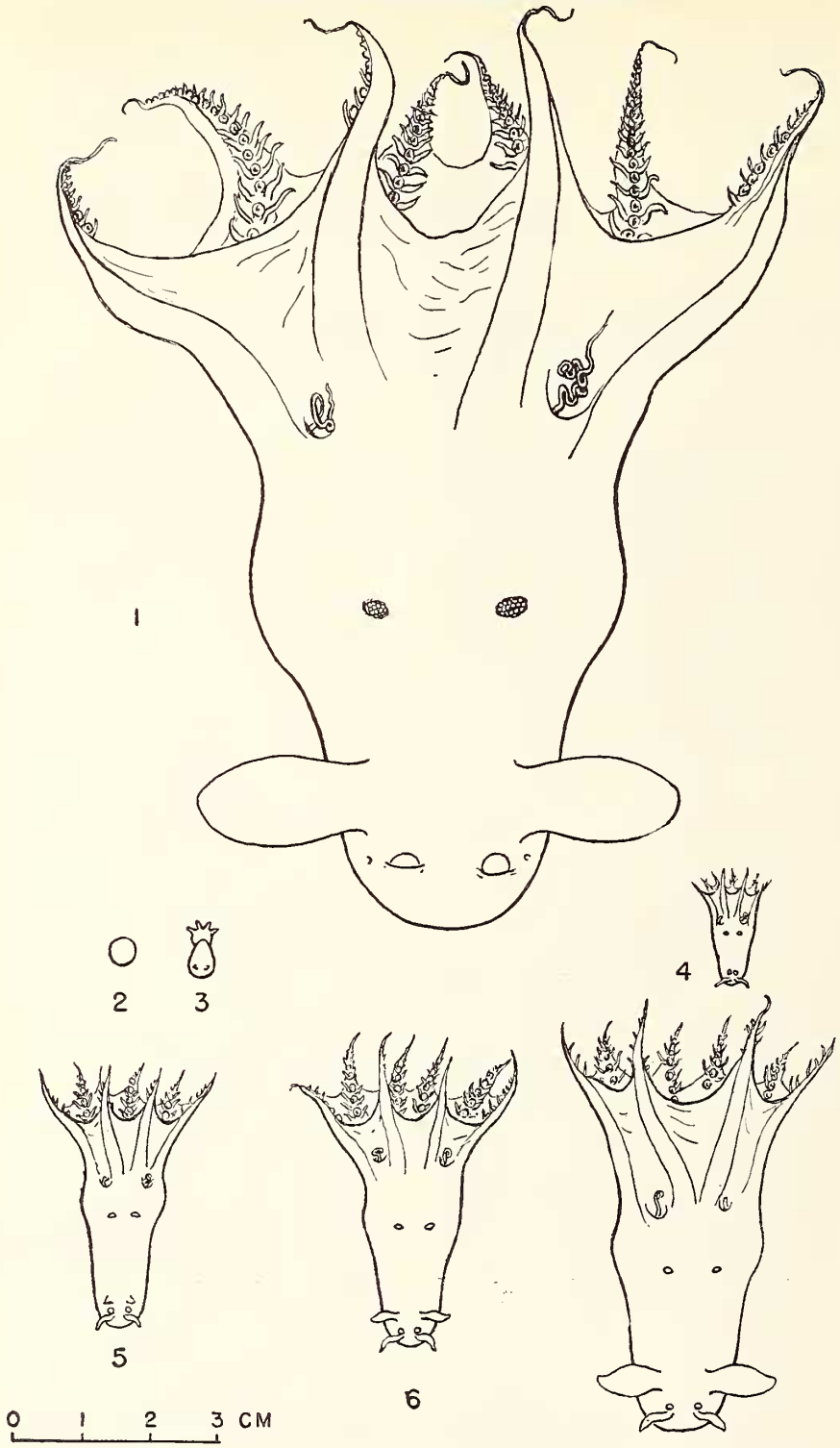
It was the good fortune of the Bermuda Oceanographic Expeditions of the New York Zoological Society, under the direction of Dr. William Beebe, to capture no less than eighteen specimens of the rather rare, bathypelagic cephalopod, *Vampyroteuthis infernalis* Chun. The addition of this new material augments the number of recorded specimens to 95, 59 of which are from the Atlantic. Moreover, Dr. Beebe's specimens, which are all larvae, constitute the largest series that has ever been taken at a single station, within so small and narrowly restricted a geographical area. Furthermore they are the only specimens ever collected for which the depth of capture is rather accurately known, having been checked with the aid of a bathygraph and not merely estimated from the length of the towline. Their capture in the Bermuda area extends the northern distribution of this species in the western Atlantic by about 8° of latitude, the nearest previous records being those of the *Pawnee* and of the *Atlantis*, somewhat to the south of this region. The comparative rarity of this animal is attested by the fact that it was taken by this expedition on only 18 occasions out of a total of more than 800 hauls at suitable depths. The collection provides a valuable opportunity for the confirmation, or rejection, of certain conclusions drawn from previous records and representing a total of 75 specimens taken from scattered stations in many different parts of the world. The present contribution is designed to lay special emphasis on this aspect of the problem.

The conditions under which the collections were made have been described by Beebe (1931a) and were summarized as follows by Coe (1945): "The collections were all made by Dr. William Beebe in a relatively minute portion of the deep subtropical Atlantic Ocean. This portion was a circular column of water eight miles in diameter, with its center located at 32° 12′ N. Lat., 64° 36′ W. Long., about nine miles southeast of Nonsuch Island, Bermuda. The nets were drawn horizontally across this area so as to collect samples simultaneously at 200-meter intervals from depths of about 1,000 to 2,000 meters. During the years 1929, 1930 and 1931 a total of 1,042 nets one meter in diameter were drawn at these depths in all directions across this eight-mile cylinder of water."

It may be useful, for the benefit of readers not already familiar with the story, to summarize some of the more interesting features in our knowledge of this remarkable animal. The biology and external morphology have been the subject of an extensive investigation, the results of which are published in the *Dana* Reports (Pickford, 1946 and 1949a). The internal anatomy, which is still under investigation, has been treated more briefly (Pickford, 1939b and 1940). *Vampyroteuthis infernalis* is an aberrant, but in many respects rather primitive and archaic dibranchiate cephalopod. It has ten pairs of arms, but the second pair is modified to form slender, sensory filaments which may be retracted into pockets on the aboral surface of the web. For this reason it cannot be placed either with the Decapoda, in which the fourth pair of arms are modified as tentacles, or with the Octopoda, which possess only eight pairs of arms. The order, or suborder Vampyromorpha Robson (emend.), to which it is assigned, thus represents a third group of dibranchiate cephalopods related, by the form of the gladius, to the extinct Prototeuthoidea.

The adult animal attains a mantle-length of 50 mm. in males, and perhaps 80 mm. in females. The head-width is nearly as great as mantle-length and the web is extensive (Text-fig. 1). The arms, like those of the Cirromorpha, bear a single row of suckers that alternate with pairs of cirri. A certain number of cirrus-pairs, the primary cirri, precede the first sucker on each arm. The external surface of the body is jet black, except for the oral face of the web which is red-brown. Near the apex of the body there is a pair of paddle-shaped fins. Just behind the base of each fin there is a circular luminous organ which may be occluded by an eyelid; on the back of the neck there are two clusters of luminous nodules and almost the whole external surface of the animal, except the oral face of the web, is decorated with minute, simple light organs.

[1] Contribution No. 873, Department of Tropical Research, New York Zoological Society.



TEXT-FIGS. 1-7. Life history of *Vampyroteuthis infernalis* Chun. **1.** Dorsal view of an adult male; the sensory filaments, representing the second pair of arms, are shown protruding from pockets in the B sectors of the web; the remnant of the resorbed larval fin is indicated by a small pocket below the fin light organ. **2.** The spherical, pelagic egg. **3.** A post-embryo; dorsal view of the youngest known specimen showing one pair of larval fins, and the squid-like, anteriorly projecting mantle margin. **4.** A typical stage 1 larva. **5.** An early stage 2 larva, showing anterior fin rudiments in front of the fin light organs. **6.** A typical four-finned, stage 3 larva. **7.** A stage 4 larva showing the animal as it appears somewhat previous to the resorption of the larval fins. All drawings to the same scale. Drawings by Lisbeth Krause.

The life history of *Vampyroteuthis* is most interesting since it undergoes what may be described as a double metamorphosis. The eggs (Pickford, 1949b) are about 3.86 mm. in diameter, spherical, and pelagic. The youngest larva ever captured (Text-fig. 3) has a mantle-length of 5.5 mm. and is provided with a slender pair of larval fins that are set diagonally so that it appears probable that the animal must swim head downwards like other larval cephalopods. A most interesting feature of this youngest stage is the forwardly projecting, squid-like, dorsal mantle-margin. In older larvae and in adults this becomes sunk within the enveloping, subcutaneous gelatinous tissue so that the animal assumes a superficial resemblance to the Octopoda.

The distinctive nature of the larval fin becomes apparent in slightly older larvae (Text-fig. 4) in which the fin light organ is developed and is found to be situated *in front* of the fin base, not behind it as in adults. At a mantle-length of about 10 mm. one can find a minute anterior fin rudiment, situated in front of the fin light organ (Text-fig. 5). The appearance of this rudiment inaugurates the second larval stage. The future adult fin grows rapidly and becomes paddle-shaped, while the length of the larval fin increases but little if at all. When the two fins are subequal, at an average mantle-length of 18 mm., the animal is considered to be in the third, or typical four-finned larval stage (Text-fig. 6). As growth proceeds the anterior fin becomes progressively larger and soon greatly exceeds the length of the larval fin; this is the fourth and last larval stage (Text-fig. 7). At a mantle-length of between 25 and 30 mm. the larval fin, whose length has scarcely changed since it became established in the 10 mm. larva, undergoes a sudden resorption. This constitutes the definitive and final metamorphosis of the larva into the adult form (stage 5) and is accompanied by many changes in the growth relationships of the bodily parts. A minute vestige of the larval fin can be found in adult animals, in the form of a little pocket situated just behind the fin light organ.

Vampyroteuthis infernalis is found in the Deep Water of all tropical and subtropical oceans. It has rarely been taken at estimated depths of less than 1,000 meters and is certainly absent from the upper 300 meters of the ocean. It is stenothermic and stenohaline and is commonly found just under the oxygen minimum, in water of density represented by σt 27.6 to 27.8. The idea that it may be restricted to a constant density layer, which was suggested to me by Dr. E. F. Thompson, appears to be confirmed by a comparison of the vertical distribution in the different oceans. Specimens from the Indo-Pacific have usually been taken at greater depths than those from the Atlantic, in water that is colder and less saline but whose density is the same as that of the layer of maximum abundance in the Atlantic. As far as is known, the eggs are also restricted to this density layer.

It seems to be quite certain that there is only one species of *Vampyroteuthis*. Previous descriptions by earlier investigators, who recognised as many as eleven species distributed among eight supposedly different genera, were based upon distorted and abnormally preserved specimens, and upon ignorance of the life history. An exhaustive study of the external characters has shown that there are no differences of a specific or even of a subspecific nature between the populations of the three great oceans. Yet there is reason to believe that the Atlantic population constitutes a distinct race, separable from the Indo-Pacific group by the average number of pairs of primary cirri on the arms. Dr. Beebe's collection of 18 specimens provides an admirable opportunity to examine this hypothesis which, it may be mentioned in anticipation, appears to receive adequate confirmation.

It is a pleasure to acknowledge my thanks to Dr. William Beebe for the privilege of examining this important and interesting series of specimens, to Dr. Gordan A. Riley for assistance with the hydrographic data, to Miss Lisbeth Krause for the drawings of the life history (Text-figs. 1-7), and to Dr. Daniel Merriman, Director of the Bingham Oceanographic Laboratory, for his continued interest in my investigations.

Seasonal Distribution, Vertical Distribution, and Hydrographic Correlations.

The specimens captured by the Bermuda Oceanographic Expeditions are listed in Table I which gives the date, net type and depth. In the last column I have given the length of the towline, obtained by doubling the estimated depth. In regard to the latter, Dr. Beebe states (in litt.) that "The bathygraph was used only occasionally to verify our estimates as to the depth of the trawling net. We found that at a speed of 2 knots and an angle of 30 degrees, the tests with the bathygraph agreed perfectly with our estimate of the depth as one-half of the amount of cable out." It is most satisfactory to have this confirmation of the estimated depth of capture, enhancing, as it does, the validity of the hydrographic interpretations which, for all other expeditions, have been based upon arbitrary assumptions.

Seasonal distribution. Previous investigations have indicated that larval vampyromorphs might be taken at all seasons, but the data were quite inadequate for a study of relative abundance. The Bermuda collections were made during the summer months, from April to October, but a tabulation of the data (Table II) indicates a period of maximum abundance in this region during June and July. The depths are tabulated but provide no evidence of vertical migration and the total numbers at all depths may therefore be considered. Comparatively few hauls at suitable depths were made in April

TABLE I.

List of Specimens.

No.[1]	Net No.[2]	Date	Net type	Depth meters	Towline meters[3]
78	331	VII.27.1929	1 metre	1,829	3,658
79	700	VI.13.1930	1 metre	1,463	2,926
80	807	VII.16.1930	1 metre	1,463	2,926
81	800	VII.15.1930	1 metre	1,463	2,926
82	710	VI.16.1930	1 metre	1,280	2,560
83	668	VI.4.1930	1 metre	1,463	2,926
84	861	IX.8.1930	1 metre	1,280	2,560
85	328	VII.27.1929	1 metre	1,463	2,926
86	731	VI.27.1930	1 metre	1,463	2,926
87	785	VII.7.1930	1 metre	1,097	2,194
88	280	VII.10.1929	1 metre	1,280	2,560
89	25	IV.15.1929	1 metre	1,463	2,926
90	788	VII.7.1930	1 metre	1,646	3,292
91	1229	VIII.27.1931	1 metre	1,463	2,926
92	724	VI.25.1930	1 metre	1,829	3,658
93	455	IX.10.1929	1 metre	1,829	3,658
94	76	V.8.1929	1 metre	1,463	2,926
95	198	VI.20.1929	2 metre	1,829	3,658

[1] Author's register of known specimens; Nos. 1-77 are listed in the *Dana* Reports (Pickford, 1946 and 1949a).
[2] Data from the published Station Lists (Beebe, 1931b, and 1932).
[3] Twice the estimated depth of capture (see text).

and the paucity of *Vampyroteuthis* at this time is, therefore, of uncertain significance. The same is not true in May when a total of 114 hauls captured only one animal. In June and July, with 186 and 146 hauls respectively, a total of 13 specimens was taken. In August, as in May, an equally extensive series of hauls captured only one specimen. The data for September are even more significant; nearly twice as many nets were lowered as in July and yet only two vampyromorphs were taken. In October, as in April, too few hauls were made to permit interpretation of the negative results.

Two interpretations are possible, either the larvae are more abundant in June and July, or they migrate into the Bermuda region at this season. The latter hypothesis receives support from two sources. Larval vampyromorphs have been taken from other parts of the Atlantic at all times of year and the otherwise rather inexplicable absence of even young adults from the Bermuda collections might be explained along these lines since there is some evidence that the larvae range more widely than the adults. However, the absence of larger specimens might be due to the fact that most of the towings were made with one-meter nets. The rich collections of the *Dana* Expeditions were made, for the most part, with two- and three-meter nets.

Vertical distribution. No specimens were taken at depths of less than 1,000 meters. This fact is significant since a total of 469 nets was lowered at depths ranging from 0-914 meters; 172 of these were at 914 meters and if *Vampyroteuthis* occurred at this depth it seems probable that at least one or two specimens would have been taken. As a matter of fact only one specimen was taken above 1,200 meters, the majority being between 1,280 and 1,829 meters (Table II). The absence of specimens at depths of more than 2,000 meters cannot be interpreted on account of the small number of hauls, but in any case such towings must have been taken in close proximity to the bottom and the concensus of previous data suggests that *Vampyroteuthis* is not commonly taken within 250 meters of the bottom.

In order to compare the vertical distri-

TABLE II.

Summary of Data on Seasonal Distribution.

Depth meters	Number of specimens							Total nets by depth
	Apr.	May	June	July	Aug.	Sept.	Oct.	
1,097	—	—	—	1	—	—	—	175
1,280	—	—	1	1	—	1	—	172
1,463	1	1	3	3	1	—	—	174
1,643	—	—	—	1	—	—	—	174
1,829	—	—	1	2	—	1	—	178
2,011-3,640	—	—	—	—	—	—	—	10
Total spec.	1	1	5	8	1	2	—	
Total nets by month	33	114	184	146	137	259	10	883

TABLE III.

Summary of Data on Vertical Distribution.

Group	Towline, in meters: 1,000-1,999	2,000-2,999	3,000-3,999	4,000 and over
Bermuda	—	13	5	—
Previous Atlantic records	3	15	10	7
Atlantic *Total*	3	28	15	7
Indo-Pacific *Total*	1	5	12	14

bution of the Bermuda collection with that of previously recorded specimens it is convenient to present the data in terms of the length of the towline (Table III). The results show that the majority of specimens was taken with towlines of between 2,000 and 3,000 meters, in good agreement with previously published records from the Atlantic and in striking contrast to the Indo-Pacific in which the majority of specimens has been taken at greater depths. However, it must be remembered that, on account of the proximity of the bottom, few towings could be made with cable lengths of more than 4,000 meters and the absence of this species at greater depths, in suitable regions, is not therefore confirmed by the Bermuda collections.

Hydrographic correlations. It will be seen from Table IV that the majority of specimens came from 1,500 meters, in water of temperature of about 4.2 °C., 35.0 ‰ salinity, and density 27.8 σt. This information is in admirable agreement with previous estimates for Atlantic specimens, the majority having been taken in water ranging from 3.0 to 6.0 °C., 34.9 to 35.0 ‰ salinity, and σt 27.6 to 27.8. The results are represented graphically in Text-fig. 8, in which the Bermuda water from which the 18 new specimens were captured is represented by a stippled rectangle. The possibility that the species may occur, in this region, in water of greater density cannot be excluded, for reasons explained under the paragraph dealing with vertical distribution but, on the other hand, it appears almost certain that it does not occur in layers of density less than σt 27.6. On the whole, the hypothesis that this species is rather narrowly restricted in its density distribution appears to receive considerable support.

It may be noted that the Bermuda specimens inhabited water that was rather well supplied with oxygen, so that the hypothesis that the species is rather oligoaerobic, although apparently supported by previous investigations, requires further confirmation.

Morphological Characters.

Measurements were restricted to mantle-length, head-width and fin-length, since it appears that there is little further to be learned from a detailed study of other external proportions. The results are given in Table V. Twelve specimens are in the second larval stage, i.e., the adult fin is present but does not exceed 60% of the length of the larval fin. Two of these 12 specimens have only a minute bud representing the anterior fin rudiment and, if they had been less well preserved, this bud might easily have been overlooked. It is probable that such a rudiment is always present in larvae of mantle-length 9 to 10 mm. and that some of the specimens previously referred to stage 1 may really have been in this transitional condition, the fin rudiment having been lost through rubbing of the skin. Four more specimens have a well developed, triangular anterior fin bud. Two specimens, Nos. 81 and 88, are of special interest; the anterior fin is only about 0.5 mm. long but has already begun to elongate and passed beyond the condition of a triangular rudiment. The

TABLE IV.

Summary of Hydrographic Data.[1]

Depth meters	Temperature °C. *a*	*b*	Salinity ‰ *a*	*b*	Density σt *a*	*b*	Oxygen cc/L *a*	*b*	Number of specimens[2]
1,000	6.76	7.20	35.075	35.08	27.53	27.48	4.3	3.88	—
1,100		5.92		.06		.63		4.56	1
1,200	5.29	.30	35.08	.04	27.72	.70	5.2	5.02	—
1,300		4.76		.03		.75		.32	3
1,400		.52		.02		.78		.60	—
1,500		.18		.01		.80		.80	9
1,600	3.96	4.00	34.99	35.00	27.81	.81	6.0	5.85	—
1,700		3.90		.00		.82		.92	1
1,800		.80		34.996		.827		.96	—
1,900		.74		.993		.833		.97	4
2,000	3.54	.66	35.04	34.99	27.89	.838	5.9	.98	—

[1] Column *a* gives actual values, taken on Aug. 27, 1931, in the exact center of the circular area in which the hauls were made (Beebe, 1933). The depths at which these determinations were made have been approximated to the nearest 100 meters, from which they differ but little; actual depths were 995, 1,194, 1,593, and 1,993 meters. Column *b* gives the average values for the Bermuda area, compiled by Dr. Gordon A. Riley (unpublished data).

[2] The depth at which a specimen was taken has been approximated to the nearest 100 meters.

smallest previously described finlet of this type was in an animal of mantle-length 18 mm. and had a length of 1.1 mm. Evidently there is some variation in the size at which the transformation occurs.

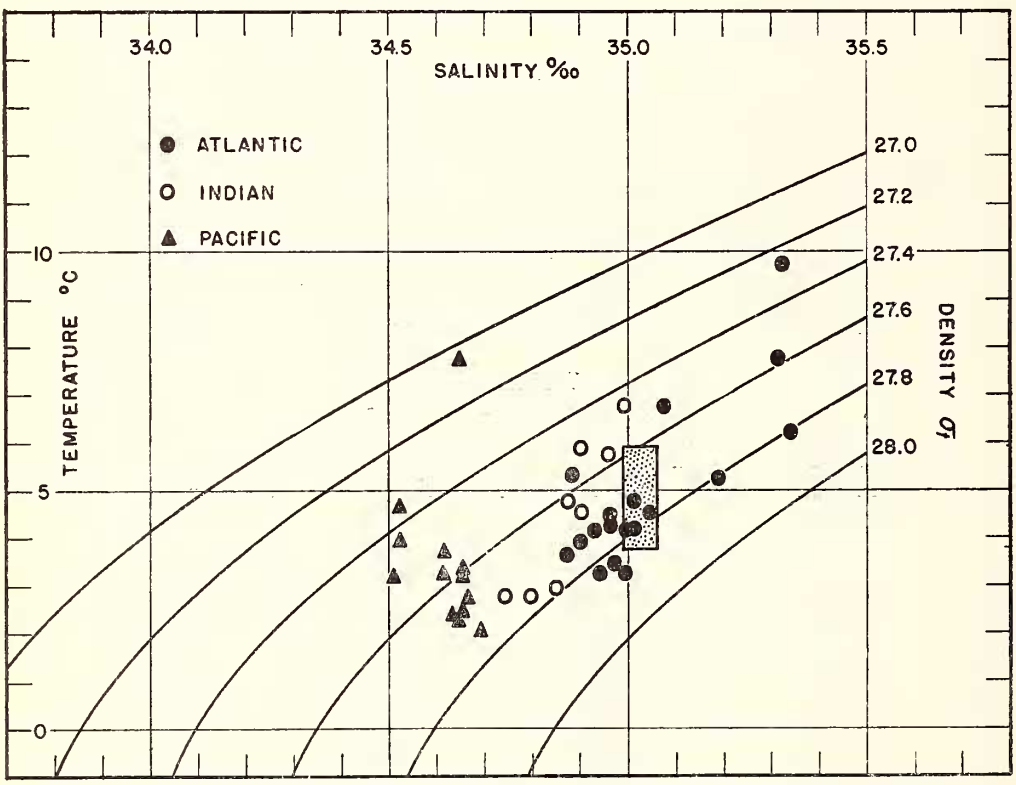
Two of the remaining specimens are in stage 3, the four-finned stage in which the fins are subequal, while the remaining four have passed over into the fourth stage.

It will be noted that in the Bermuda larvae, as in previously described specimens, the average length of the larval fin remains constant throughout stages 2, 3 and 4. The average length is somewhat less than in previously studied specimens, 3.34 as against 3.86 mm. This may be due to the method of preservation as all Dr. Beebe's specimens appear to be somewhat contracted, whereas the *Dana* specimens tended to be relaxed and, possibly, a little swollen from preservation in neutral sea-water formalin. It may also be added that the fin was frequently rubbed and twisted so that measurement was difficult. Apart from this small difference, the thesis that the larval fin virtually ceases to grow after it has been fully formed receives adequate confirmation. The onset of the development of the anterior fin is coincident with the cessation of growth of the larval fin.

The relationship between mantle-length and fin stage is summarized in Table VI. In stage 2, which is represented by an adequate series of specimens, the range and mean mantle-length of the Bermuda series is in remarkably close agreement with the range and mean for those previously described. The agreement is also good for the four stage 4 specimens and the two stage 3 animals are within the range for those hitherto described.

Previous studies of head-width indicates that the head is relatively narrower in larval animals. This receives adequate confirmation from the new material (Table VII). At stage 2 the average head-width index for the Bermuda series is 68.4, as compared with 69.0 for 17 previously described animals. The two stage 3 Bermuda specimens happen to have rather wide heads while the mean for the four stage 4 specimens is below the average for those studied previously. However, in both cases the range is within the known range for these stages and differences in the means must be attributed to the small numbers. All are below the mean values for adults in which head-width is almost equal to mantle-length. The thesis that head-width is relatively narrower in larval animals is fully substantiated.

Great interest attaches to the number of pairs of primary cirri, i.e., the cirri that precede the first sucker, on the arms. The finding for the Bermuda specimens are therefore presented in detail in Table VIII, and ana-



TEXT-FIG. 8. The distribution of *Vampyroteuthis infernalis* Chun in relation to temperature, salinity and density. The character of the Bermuda water, from which Dr. Beebe's 18 specimens were taken, is indicated by a stippled rectangle but the individual records are not plotted.

TABLE V.

Mantle-length and Other Morphological Characters.

No.	Mantle-length mm.	Sex	Stage	Head-width index	Ant. fin length mm.	Post. fin length mm.
78	9.5	?	2	60.5	rud.	c.2.1
79	10.0	♂	2	70.0	rud.	c.3.0*
80	10.5	♀	2	81.0	?	3.2
81	c.11.5	♂	2	65.2	0.4	3.0
82	12.0	♂	2	60.8	△	3.5
83	12.5	♂	2	68.0	1.0*	c.2.8*
84	13.0	♀	2	53.8	△	3.0
85	13.5	♀	2	88.9	1.1	2.8
86	13.5	♂	2	70.4	△	3.5
87	13.5	♀	2	63.0	△	4.5
88	14.0	♀	2	52.6	0.6	3.0
89	15.0	♂	2	86.5	1.6	4.0
90	c.15.0	♀	3	80.0	4.3	3.4
91	18.0	♂	3	94.5	8.1	5.0
92	21.0	♂	4	76.2	6.5	3.0
93	22.5	♀	4	77.8	6.5	4.0*
94	23.5	♂	4	78.7	10.5	3.0
95	c.26.0	♂	4	76.8	Very damaged, ant. prob. 4 times length of post.	

* Left fin in better condition and measured instead of right.

△ Anterior fin represented by a triangular rudiment, more advanced than the minute bud seen in specimens No. 78 and 79.

TABLE VI.

Summary of Data on Mantle-length in Relation to Stage[1]

Stage	Bermuda collection		All previous records	
	No.	Mantle-length mm.	No.	Mantle-length mm.
1	—	—	7	5.5-*6.9*-9.0
2	12	9.5-*12.4*-15.0	18	8.0-*12.1*-18.0
3	2	15.0-*16.5*-18.0	10	15.0-*18.1*-26.5
4	4	21.0-*23.3*-26.0	5	19.0-*23.0*-27.0
5♂♂	—	—	15	27.0-*40.6*-55.0
5♀♀	—	—	12	25.0-*36.0*-63.0

[1] Range and *mean* (italics).

TABLE VII.

Summary of Data for Head-width Index in Relation to Stage.[1]

Stage	Bermuda collection		All previous records	
	No.	Head-width index	No.	Head-width index
1	—	—	8	43.6-*69.1*-95.0
2	12	52.6-*68.4*-88.9	17	51.4-*69.0*-95.0
3	2	80.0-*87.3*-94.5	11	50.0-*69.2*-102.5
4	4	76.2-*77.4*-78.7	6	73.5-*84.5*-97.9
4-5	—	—	6	82.5-*98.8*-118.5
5	—	—	21	76.0-*93.9*-112.0

[1] Range and *mean* (italics).

TABLE VIII.

Number of Pairs of Primary Cirri.

Note: Irregularities are frequent and cannot be described in detail; a cirrus pair is often represented by a single cirrus or, less commonly, by three cirri resulting from bifurcation of one member of the pair.

	Left arms				Right arms			
No.	1	2	3	4	1	2	3	4
78	———		Not possible to count					———
79	7	7	6	6	??7	—	7	—
80	8	7	7	7	7	—	8	8
81	8	8	7	6	8	—	7	7
82	8	—	5	6	—	—	6	6
83	8	7	—	6	8	7	7	6
84	—	—	—	8	9	8	9	8
85	7	—	6	6	7	6	6	6
86	9	8	6	6	9	8	8	—
87	9	7	6	6	—	8	6	6
88	8	8	7	7	7	7	6	6
89	9	7	7	7	10	8	8	8
90	10	8	7	6	—	—	7	7
91	8	—	—	6	7	6	6	6
92	8	7	6	6	8	7	6	6
93	8	7	7	7	7	7	7	7
94	7	7	6	—	8	7	7	6
95	—	6	6	6	8	6	7	6

lyzed in Tables IX and X. As in previously described specimens, the maximum number of primary cirri is usually on the first arms; a second or third arm may occasionally participate and there is one specimen, No. 80, in which both the third and fourth right arms have as many pairs of primary cirri as the first left, while the first right has one less. This is the first time that a fourth arm has shared in the tabulation of the maximum number of primary cirri.

A further point of interest is that two of the newly described specimens have as many as ten pairs of primary cirri on at least one of the first arms. Among previously described specimens there was evidence that a tenth pair might have been present on the first right arm of the Monaco female (specimen No. 2). In specimen No. 89 of the Bermuda series there can be no doubt that ten pairs occur on the first right arm, the state of preservation being so perfect that there is no possibility of uncertainty. The first left arm has only nine pairs. In specimen No. 90 the first pair on the first left arm is represented by a single cirrus, a frequent abnormality, and this is followed by nine more pairs preceding the first sucker.

In previously described animals the minimum number of primary cirri is shared equally between the third and fourth arms, the first and second arms participating only very occasionally. The same is true of the Bermuda series.

The special interest of the number of primary cirri lies in the fact that Atlantic specimens appear to have an additional pair on all arms. The data for the maximum number will be considered first (Table IX). Many of the previously described Atlantic specimens had a maximum of only seven pairs, but nearly all of the newly described animals have eight or more. The new data therefore not only confirms but amplifies the previous findings. Thirty out of 41 Atlantic specimens have a maximum of eight or more pairs of primary cirri, the peak being at eight, whereas 14 out of the 23 Indo-Pacific specimens have only seven.

The over-all data for the minimum number of primary cirri tells the same story (Table X). Only five out of 26 Indo-Pacific specimens have a minimum of as many as six or more whereas this condition is typical for the Bermuda series, confirming and amplifying the sum total of data for the Atlantic. The analysis of previous material provided some evidence that young Atlantic animals tended to have a smaller minimum number of primary cirri than adults. Nine out of 20 larvae had a minimum of only five pairs whereas none of the seven adults had less than six. Since all the Bermuda specimens are larvae, and all but one have a minimum of six pairs, the hypothesis advanced previously, that there is a difference in this respect between larvae and adults, does not receive confirmation and must be withdrawn.

TABLE IX.

Summary of Data on Maximum Number of Pairs of Primary Cirri.

Group	Maximum number of pairs of primary cirri 6	7	8	9	10	Total number specimens
Bermuda	—	2	10	3	2	17
Previous Atlantic records	—	9	9	6[1]	—	24
Atlantic *Totals*	—	11	19	9[1]	2	41
Indo-Pacific *Totals*	1	14	8	—	—	23

[1] Includes one specimen that may have possessed a tenth pair (Pickford, 1939a).

SUMMARY.

Eighteen larval specimens of *Vampyroteuthis infernalis* Chun were taken by the Bermuda Oceanographic Expeditions at depths ranging from 1,097 to 1,829 meters. The estimated depth of capture, at one-half the length of the towline, was confirmed with the aid of a bathygraph. No specimens were taken in numerous hauls at depths of less than 1,000 meters, and none were taken in a limited number of hauls at over 2,000 meters The region of maximum abundance, between 1,000 and 1,500 meters (2000 to 3,000 meters towline) is in accordance with previous data for the vertical distribution of this species in the Atlantic, estimated from the length of the towline but without collateral confirmation.

TABLE X.

Summary of Data on Minimum Number of Pairs of Primary Cirri.

Group	Minimum number of pairs of primary cirri 4	5	6	7	8	Total number specimens
Bermuda	—	1	12	3	1	17
Previous Atlantic records	—	11	16	4	—	**31**
Atlantic *Totals*	—	12	28	7	1	**48**
Indo-Pacific *Totals*	4	17	4	1	—	26

Collections were made during the months of April to October; there is a pronounced maximum in June and July, but the interpretation of this is uncertain.

Hydrographic conditions at the known depths of capture are in agreement with the optimum temperature, salinity and density of the water that is characteristically inhabited by this species in the Atlantic. The hypothesis that the species tends to be restricted to a density layer of σt 27.6 to 27.8 is confirmed. The hypothesis that the species is oligoaerobic, as indicated by previous investigations, remains open since Dr. Beebe's specimens were taken in water that was not deficient in oxygen.

The average length of the larval fin is somewhat less than that calculated for previous specimens, 3.34 mm. as compared with 3.86 mm., perhaps due to the state of preservation. The hypothesis that growth of the larval fin virtually ceases at a mantle-length of about 10 mm., concomitant with the appearance of the anterior fin rudiment, is confirmed. The relationship between mantle-length and fin-stage is in agreement with previous descriptions, and the hypothesis that the head-width index is less in larval than in adult animals is confirmed. The hypothesis that Atlantic specimens have one more pair of primary cirri on the arms, as compared with the Indo-Pacific population, is confirmed, but the hypothesis that larval Atlantic specimens have a smaller minimum number of primary cirri than adults must be rejected.

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